

**Final Report  
For NASA Contract  
NAS5-32349**

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SOURCE SYSTEM Final Report  
(Labsphere) 25 p

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16. Abstract  <p>The purpose and scope of this final report is to provide information on the Custom Uniform Source System (CSTM-USS-4000). The report includes documentation and summaries of the results for the work performed under the contract. The Annex contain laboratory test findings, photographs, and drawings of the sphere system.</p>		
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## **1.0 GENERAL OVERVIEW**

The purpose and scope of this final report is to provide information on the Custom Uniform Source System (CSTM-USS-4000). The report includes documentation and summaries of the results for the work performed under the contract. The Annex contain laboratory test findings, photographs, and drawings of the sphere system.

### **1.1 Introduction**

In early February 1993, Labsphere was contacted by NASA with a requirement for a uniform radiance source to cover the spectral range from 300 to 2500 nm. At that time, a system with a Spectrafect™ coated integrating sphere was discussed. Labsphere was informed later that a Spectralon™ tiled or PTFE lined sphere may be desired. In December 1993, NASA ordered a 40 inch Custom Unified Source sphere system.

### **1.2 Functional System Description**

The system consists of the following two major subsystems.

#### **1.2.1 Integrating Sphere Assembly**

The Custom Uniform Source System is designed to provide uniform radiance over the entire exit port of the 40 inch sphere. Sixteen 45 watt halogen lamps, powered by four LPS-200-H Halogen Lamp Power Supplies, illuminate the sphere. Three SDA-050-U Silicon Detector Assemblies monitor the output of the sphere. The signals from the detectors are monitored by the DM-1000 Detector Multiplexers and interpreted by the SC-5000 Integrating Sphere System Control.

#### **1.2.2 Sphere Electronic Control System**

The integrating sphere will be connected to the Sphere Electronic Control Module. This module will provide power to the lamps and monitor the signals generated by the detectors. This module will be comprised of 16 LPS-045-II Precision Lamp Power Supplies, one SC-5000 System Control, and one DM-1000 Detector Multiplexer mounted in one or more electronics mounting rack(s). This entire module will require 120 volts ac, 60 Hz, power input.

### **1.3 Summary of Results**

The CSTM-USS-4000 meets and exceeds all performance specifications according to laboratory results. The system achieved the minimum spectral radiance output (radiance of the aperture) of  $36.0 \text{ W}\cdot\text{cm}^{-2}\cdot\text{nm}^{-1}\cdot\text{sr}^{-1}$  at 700 nm. and achieved the radiance uniformity (over aperture) of greater than 98%.

The Spectral Radiance for the sphere from 300 nm. to 2400 nm. can be found in Table 1 of Report number 10717-2-1 of Annex A. The system achieved  $69.5 \text{ W} \cdot \text{cm}^{-2} \cdot \text{nm}^{-1} \cdot \text{sr}^{-1}$  at the 700 nm. wavelength with an estimated total instrument uncertainty of 2.3%.

The Photopic Uniformity Mapping for the sphere exit port aperture is found in Table 1 of Report number 10717-3-1 of Annex A. The system achieved 99% +/- 0.5% radiance uniformity of the exit port with all lamps operating.

## 2.0 SYSTEM DESCRIPTION

The custom uniform source sphere system includes an SC-5000 Integrating Sphere System Control and two DM-1000 Detector Multiplexers. Modifications have been made to all of these units to better integrate and simplify the system. The following is a list of all components within the system.

### System Components

- 40-inch Sphere Assembly
- 16 IHLS-100-45 Internal Halogen Light Sources
- 3 SDA-050-U Silicon Detector Assemblies
- 3 Narrow Band Filters - 450 nm, 650 nm and 950 nm Center Wavelength
- 1 SC-5000 Integrating Sphere System Control
- 4 LPS-200-H Lamp Power Supplies
- 2 DM-1000 Detector Multiplexers
- 6 Power Cords
- 3 Detector Cables
- 4 Lamp Power Cords

## 2.1 Spectralon™ Tiled Integrating Sphere

The integrating sphere assembly is comprised of an integrating sphere, with internally mounted lamps and externally mounted detectors, mounted in an adjustable carriage.

### 2.1.1 Integrating Sphere

The integrating sphere has an approximate outer diameter of 40 inches with an exit aperture of 14 inches. Internal to the sphere, a quantity of sixteen 45 watt lamps are mounted concentrically around the exit port on the front hemisphere. Three silicon detectors are mounted on the front hemisphere. Also on the front hemisphere, hardware is mounted to allow for the attachment of the two exit port apertures.

The sphere is mounted in a height-adjustable carriage with locking casters. This carriage allows the center line of the exit port to be adjusted plus or minus 12 in. from a nominal height of 48 in. On two of the swiveling casters, a mechanism for locking the swiveling function has been provided. In this way, two of the casters can be locked in the horizontal position so that the sphere's location can be adjusted on this axis. The other two casters have a standard locking mechanism that locks the sphere firmly into place. Figure 1 shows the integrating sphere in its carriage.

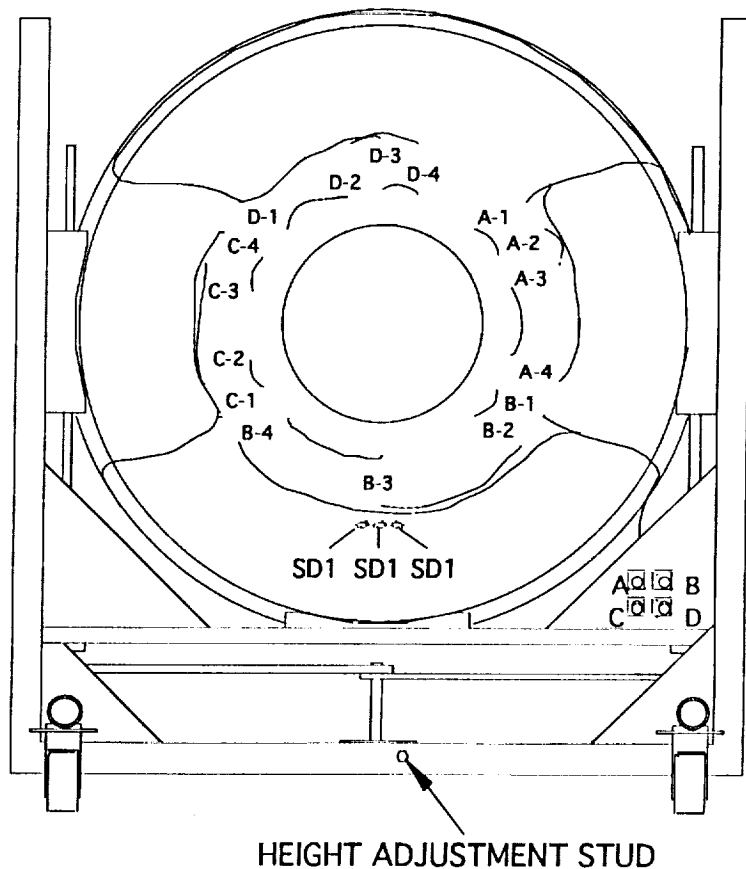


Figure 1. Front View of Custom USS-4000 Integrating Sphere

In order to line the interior of the sphere with Spectralon, Labsphere started with Spectralon tiles, machined into an octagonal shape, approximately 5.0 in. across and 3/8 in. thick. These tiles were mechanically fastened to the interior of a 40 in. diameter sphere. Because of the thickness of the tiles, the inner diameter of the sphere was reduced to about to approximately 39 inches.

The tiles are held in place with a fastener, inserted from the exterior of the sphere into the Spectralon tile. Specially designed tiles have been used to allow for the mounting and wiring of the lamps and detectors. After the tile installation was completed, the entire inside surface of the sphere was wet-sanded and cleaned to minimize the optical performance impact of the seams between the tiles.

### 2.1.2 Spectralon™

Spectralon™ is a PTFE based, machinable thermoplastic that exhibits a high and relatively flat spectral reflectance over the spectral range from 250 to 2500 nm. Spectralon was the most durable of the three coatings originally proposed. Spectralon is hydrophobic and thermally stable up to temperatures of 350°C plus.

## 2.2 SC-5000 Integrating Sphere System Control

The SC-5000 Integrating Sphere System Control is internally wired to the DM-1000 Detector Multiplexers. Therefore, some of the connections on the back panel do not correspond with the SC-5000 instruction manual.

- The Digital Output Control connector is not used to interface the SC-5000 to any other component. The connection to the DM-1000 is made internally.
- The Detector Inputs on the back panel of the SC-5000 are blanks. See Figure 2. These inputs are not connected and will not work with any detector. All detector connections to the SC-5000 from the DM-1000 for this system are made internally.

## 2.3 DM-1000 Detector Multiplexer

The DM-1000 Detector Multiplexers are internally wired to each other and to the SC-5000 Integrating Sphere System Control. Both the front panel and the back panel of the DM-1000s differ from the standard control as described in the DM-1000 Detector Multiplexer Manual.

DM-1000 #1 has no back panel controls or connectors. The front panel contains LED's labeled Voltage 1, 2, 3 and 4 and Current 1, 2, 3 and 4. DM-1000 #1 monitors the voltage and the current of each of the four banks of lamps. A lit LED for Voltage 1 indicates that the voltage across the line going to lamp bank #1 is being monitored. A lit LED for Current 1 indicates that the current through the lamps of bank #1 is being monitored.

The front panel of DM-1000 #2 contains LEDs labeled SD1, SD2 and SD3 and Ch1, Ch2, Ch3, Ch4 and Ch5. A lit SD# LED indicates which detector is being monitored. Ch2 is connected to DM-1000 #1. A lit Ch2 LED indicates that DM-1000 #2 is receiving voltage and/or current information from DM-1000 #1 and sending it through the SC-5000 to a personal computer. The other LEDs indicate monitoring of any other instrument attached to the Ch# connectors on the back panel of the DM-1000 #2.

The DM-1000 Detector Multiplexers cannot be used without a personal computer. The system can be used as a uniform source without a personal computer. However, because the detectors interface with the DM-1000, the SC-5000 is not capable of displaying the output of the detectors without a personal computer.

When developing software to run this system, the following precautions must be taken.

- A DM-1000 Detector Multiplexer should only communicate to one port at a time. Any other communication will damage the system.

- A program must contain a delay when instructing the DM-1000 Detector Multiplexer to switch detectors monitored. The DM-1000 normally operates slower than most computers and must have adequate time to obtain, display and transfer the appropriate reading to the computer before it receives another instruction.
- When instructing the DM-1000 to change its monitoring from Current to Current, Current to Voltage, Voltage to Current or Voltage to Voltage, the input must be disabled first. After the change is made, the input must be enabled.

#### 2.4 SDA-050-U Silicon Detector

This Uniform Source System has three SDA-050-U Silicon Detector Assemblies. Each detector consists of a silicon photovoltaic detector which is mounted in a housing and designed for monitoring light within the sphere. The detector assemblies were shipped attached to the sphere with narrow band filters in place. The following table shows the placement of the filters with the listed wavelengths.

Detector Assembly	Center Wavelength of Filter
SD1	450
SD2	650
SD3	950

Each detector assembly is secured to a 0.5 inch port frame located at the front of the sphere (see Figure 1). To remove the detector assembly, loosen the two set screws on the assembly.

The detectors are connected to the back panel of the DM-1000 with detector cables that have BNC connectors on both ends.

#### 2.4 LPS-045-H Halogen Lamp Power Supply

The LPS-045-H Halogen Lamp Power Supplies will provide a precision regulated DC constant current to within 0.1% of the set current. The power supplies also incorporate a ramp up feature that, when activated, slowly applies the current to the lamp over an interval of at least 45 seconds. The current and voltage to the lamps is monitored internally to the LPS-045-H and are displayed on the LCD screen. Additional information regarding these power supplies can be found in the applicable manual.

### 3.0 SYSTEM OPERATION

The Custom Uniform Source System is designed to achieve uniform radiance. Each power supply controls one bank of four lamps. To achieve desired outputs, turn on a combination of power supplies that approximates the desired output.



### **3.1.1 Sphere**

The mounting scheme of the USS-4000 Uniform Source System is intended for floor use. The sphere is mounted to a steel frame that is connected to a sturdy square base with casters for facilitated movement. The sphere's height may be adjusted by turning the height adjustment handle at the center of the sphere carriage (see Figure 1).

### **3.1.2 DM-1000 Detector Multiplexer**

The DM-1000 Detector Multiplexer is used to multiplex the signal from the three detectors to the SC-5000 system control. The user will have the option of either monitoring all three detector sequentially or to lock on to any one of the three detectors. Additional information on the DM-1000 Detector Multiplexer can be found in the applicable manual.

### **3.1.3 SC-5000 System Control**

The SC-5000 System Control provides the read out for the detectors as well as provides the interface from the NASA supplied computer to the power supplies and the detector multiplexer. The SC-5000 has both an IEEE-488 and a RS-232 computer interface built in. Through the SC-5000, the user will have access to the on/off function on all of the power supplies, the functions on the detector multiplexer, and all the functions in the SC-5000 itself, via a computer. Additional information on the SC-5000 System Control can be found in the applicable manual.

## **4.0 SYSTEM DOCUMENTATION**

Labsphere has provided the following system documentation.

### **4.1 System Manual**

The system manual provided with the sphere, gives instructions for connecting the system's power and interfacing cables.

Instructions on how to manually and remotely operate the SC-5000 Integrating Sphere System Controls, DM-1000 Detector Multiplexer and LPS-045-H Halogen Lamp Power Supplies are contained in the manuals specific to those instruments.

### **4.2 Calibration Certificate**

This document provides the actual calibration values based on instrumentation readings in Labsphere's Optical Calibration Laboratory. The equipment and methods used in this laboratory are traceable to the U.S. National Institute of Standards and Technology (NIST).

#### 4.3 System Drawings

System Drawings are attached as Annex C and include the following drawings:

- CY-01446-060 SPHERE ASSY,CSTM-US-400-SL-TILED (2 Sheets)
- CY-01447-000 CARRIAGE ASSY, HA-400

Drawings are identified by a unique Labsphere part number. The explanation of the numbering system is as follows:

CY-XXXXX-YYY

CA = Customer Assembly

CY = Customer Subassembly

CM = Customer Machined Part

XXXXXX is sequential number assigned.

YYY is lower level number

ANNEX A CALIBRATION CERTIFICATE

ANNEX B SYSTEM PHOTOGRAPHS

ANNEX C SYSTEM DRAWINGS

Doc. No: LAB.RP.10717-1  
Issue: Final  
Date: 02/15/94

# **ANNEX A**

## **CALIBRATION CERTIFICATE**

# CALIBRATION CERTIFICATE

REPORT NUMBER: 10717-2-1  
DATE OF CALIBRATION: 01/03/93  
PAGE 1 OF 3

RENDERED TO: NASA Goddard Space Flight Center  
AUTHORIZATION: Purchase Order NAS5-32349  
CALIBRATION LABORATORY: Labsphere, Inc., Optical Calibration Laboratory

CALIBRATED SYSTEM OR STANDARD  
CSTM-USS-4000, Custom Uniform Source, Serial Number: 002309

CALIBRATION REQUESTED  
USC-SR, Spectral Radiance

APPLICABLE DOCUMENTS  
MIL-STD-45662A  
Labsphere #QP-13001-00 Final Visual/Mechanical Inspection

## TEST AND TEST METHOD

The spectral radiance of the sphere is calibrated with equipment and methods traceable to the U.S. National Institute of Standards and Technology (NIST). Data is presented from 300-2400nm. The calibration is valid for 50 hr's. of operation. The radiance drift is approximately 1% for 50 hr's. after warm-up for most wavelengths. The measuring instrument is a scanning, dispersive spectroradiometer. A three mirror input optics system illuminates a diffraction grating monochromator. Long pass order sorting filters are used at the entrance slit to reduce stray light. A mechanical chopper provides a modulated reference signal. The complete spectral measurement range requires two photo detectors and two diffraction gratings. Signal conditioning electronics include low noise, high impedance preamplifiers and a single phase lock-in amplifier. Instrument calibration is performed by viewing a diffuse target of known spectral reflectance illuminated by a calibrated lamp of known spectral irradiance. The reference radiance is given by the product of the target reflectance and the lamp irradiance divided by  $\pi$ . The measured field-of-view is 25 mm x 6 mm. Spectral radiance measurements are performed for this field of view positioned at the center of the plane of the integrating sphere exit port.

CALIBRATION RESULTS  
See Table I "Spectral Radiance"

ESTIMATE CALIBRATION UNCERTAINTY  
See Table II "Estimated Spectroradiometer Uncertainty"

CAUTION:  
This calibration is only valid for the lamp used in the calibration.  
Do not touch the bulbs with bare hands as the oils in the skin may damage the lamps.

This certificate shall not be reproduced except in full, without the written approval of Labsphere, Inc.

Calibrated by: *[Signature]*  
Title: OPTICAL CALIBRATION TECHNICIAN  
Date: 1/4/94

Approved by: *[Signature]*  
Title: Optical Calibration Engineer  
Date: 01/04/94

**labsphere**

P.O. Box 70 No. Sutton, N.H. 03260  
Tel 603-927-4266  
Fax 603-927-4694

# CALIBRATION CERTIFICATE

REPORT NUMBER: 10717-2-1  
DATE OF CALIBRATION: 01/03/93  
PAGE 2 OF 3

Table 1  
Spectral Radiance

Wavelength nm	CSTM-USS-4000 All Lamps Operating Spectral Radiance $\mu\text{W}/\text{cm}^2\text{-sr-nm}$
300	0.594
310	0.863
320	1.06
330	1.27
340	1.66
350	2.11
400	6.08
450	13.4
500	23.8
555	36.7
600	47.7
655	60.2
700	69.5
800	84.2
900	89.9
1050	93.0
1150	92.7
1200	89.8
1300	82.2
1540	59.2
1600	52.9
1700	42.6
2000	23.1
2100	17.2
2300	14.4
2400	11.8

The CSTM-USS-4000 calibration is only valid with the IHLS-DM-045SL, 45W lamps operating at 6.60 amps.

**labsnhere**

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# CALIBRATION CERTIFICATE

REPORT NUMBER: 10717-2-1  
DATE OF CALIBRATION: 01/03/93  
PAGE 3 OF 3

Table II  
Estimated Spectroradiometer Uncertainty

	3 sigma fractional uncertainty in percent						
Wavelength	350 nm	654.6 nm	900 nm	1300 nm	1600 nm	2000 nm	2400 nm
Systematic Errors							
Irradiance of Standard Lamp	1.22	1.13	1.47	1.57	2.01	3.37	6.55
Target Reflectance	1.5	1.5	1.5	1.5	1.5	1.5	6.0
Non-Linearity of Detectors/Amplifiers	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Random Errors							
Lamp Current Setting	0.19	0.19	0.19	0.19	0.19	0.19	0.19
Lamp Current Drift	0.06	0.03	0.02	0.02	0.01	0.01	0.01
Lamp Reference Distance	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Monochromator Wavelength Setting	0.85	0.49	0.33	0.92	0.75	0.60	0.50
Total Precision	1.06	0.80	0.71	1.11	0.98	0.87	0.80
Total RSS Measurement Uncertainty	2.42	2.27	2.43	2.64	2.87	3.92	9.01

**labsphere**

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REPORT NUMBER: 10717-3-1  
DATE OF CALIBRATION: 01/03-94  
PAGE 1 OF 2

RENDERED TO: NASA Goddard Space Flight Center  
AUTHORIZATION: Purchase Order NAS5-32349  
CALIBRATION LABORATORY: Labsphere, Inc., Optical Calibration Laboratory

## CALIBRATED SYSTEM OR STANDARD

CSTM-USS-4000, Custom Uniform Source, Serial Number: 002309

## CALIBRATION REQUESTED

USC-PM, Photopic Uniformity Mapping

## APPLICABLE DOCUMENTS

MIL-STD-45662A

Labsphere #QP-13001-00 Final Visual/Mechanical Inspection

## TEST AND TEST METHOD

Uniformity mappings are performed in the Optical Calibration Laboratory. All calibrated equipment used for the calibration has traceability to the National Institute of Standards and Technology.

The calibration is performed using a telephotopic luminance meter mounted on an XY station set-up at a distance of 6 inches, to scan the exit port of the sphere imaging the integrating sphere exit port with a 2mm diameter spot size.

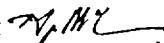
Data point separation is 0.1 of the exit port diameter. Data is presented as a map normalized to the luminance at the center position of the exit port.

## CALIBRATION RESULTS

See Table 1

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Calibrated by   
Title: OPTICAL CALIBRATION TECHNICIAN  
Date: 1/4/94

Approved by:   
Title: Optical Calibration Engineer  
Date: 01/04/94

**labsphere**

P.O. Box 70 No. Sutton, N.H. 03260  
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# CALIBRATION CERTIFICATE

REPORT NUMBER: 10717-3-1  
DATE OF CALIBRATION: 01/03-94  
PAGE 2 OF 2

Table 1  
Axial Uniformity Mapping

Luminance at the center of the exit port: 7380 foot-lamberts

										Map Key				
		I	F	E	E	G				A	100.0%			
		G	D	B	B	B	C	G				B	99.9%	
J	G	B	A	A	A	B	B	G				C	99.8%	
		D	A	A	A	A	A	B	F				D	99.7%
I	D	A	A	A	A	A	A	B	F				E	99.6%
		C	A	A	A	A	A	C	E				F	99.5%
H	C	A	A	A	A	A	A	C	E				G	99.4%
		D	B	A	A	A	B	C	E				H	99.3%
I	D	B	A	A	A	B	C	E				I	99.2%	
		E	B	B	B	B	C	E	I				J	99.1%
J	E	B	B	B	B	C	E	I				K	99.0%	
		H	E	C	B	C	E	G						
		K	G	F	F	H								

The calibration was performed with all lamps operating.  
The 10 inch diameter exit port aperture plate was mounted through the calibration

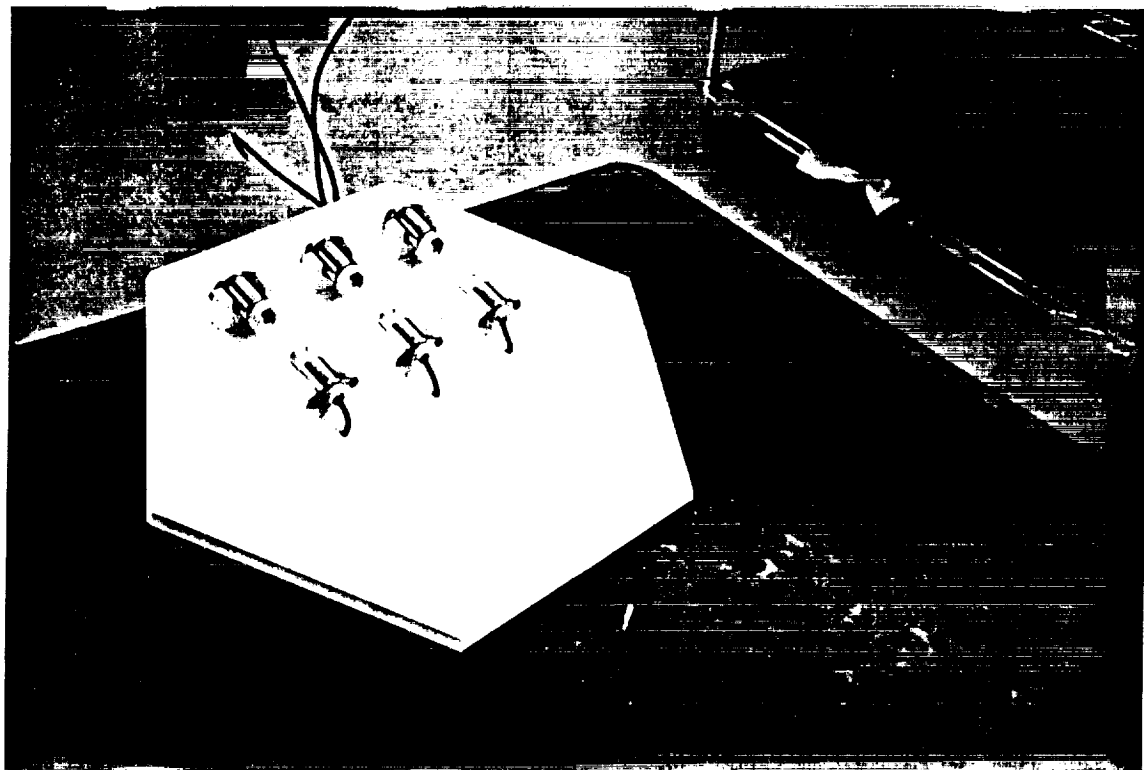
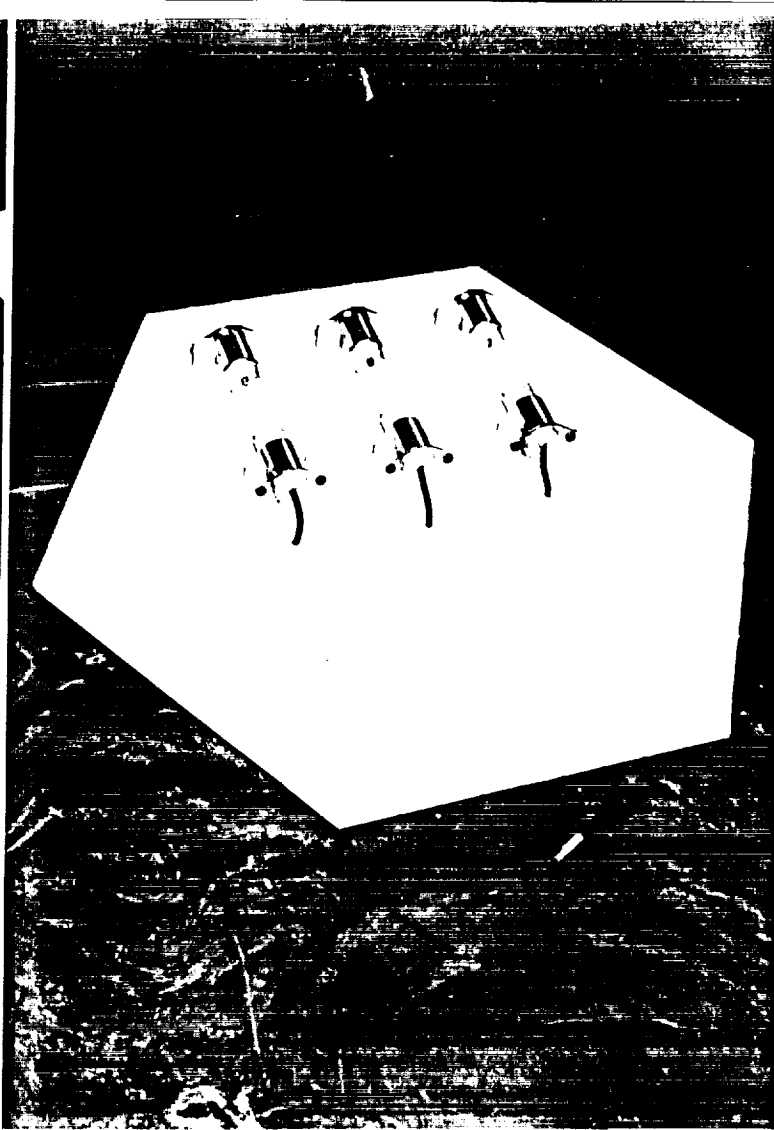
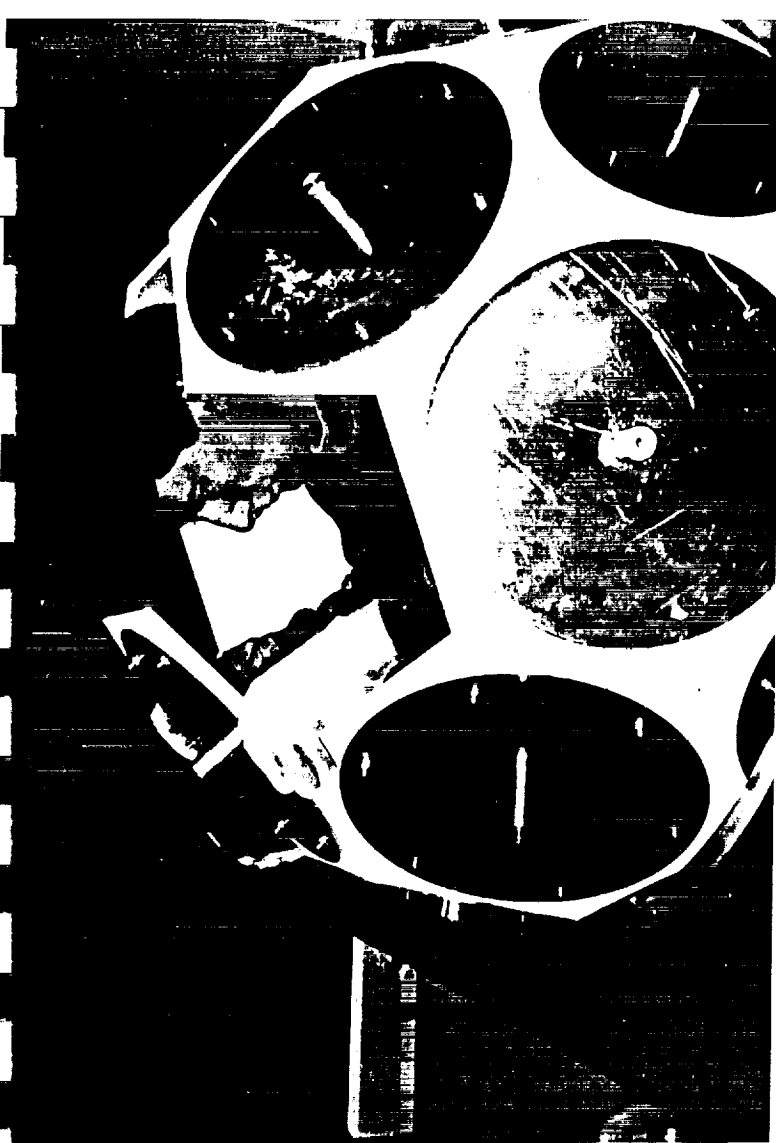
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Doc. No: LAB.RP.10717-1  
Issue: Final  
Date: 02/15/94

# **ANNEX B**

## **SYSTEM PHOTOGRAPHS**



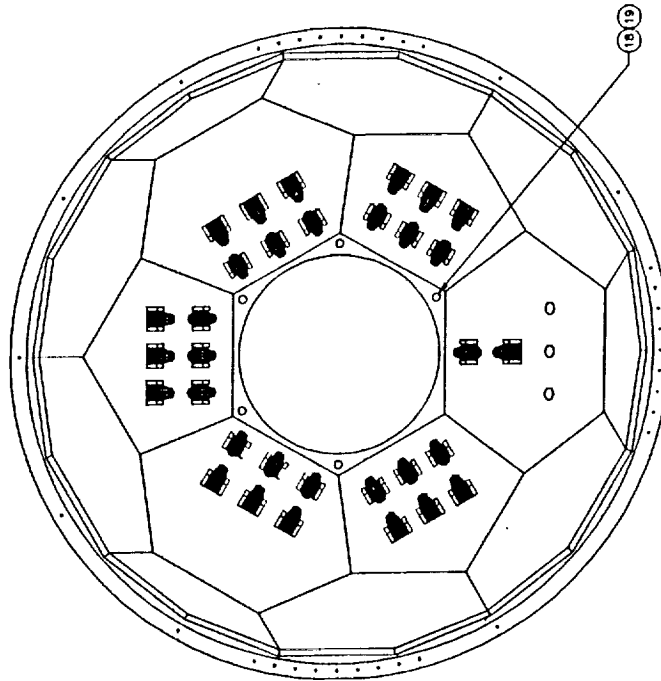
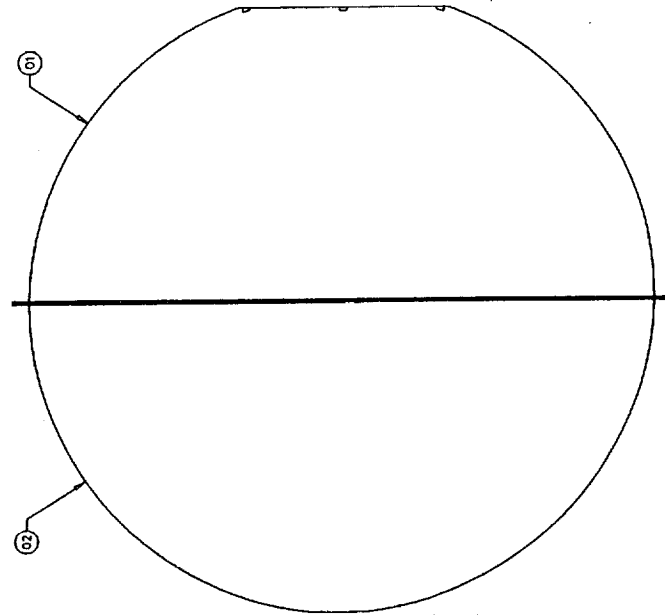
Doc. No: LAB.RP.10717-1

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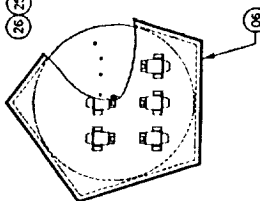
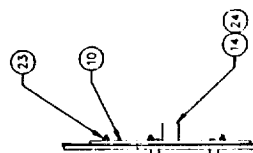
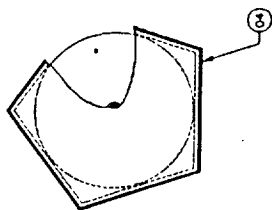
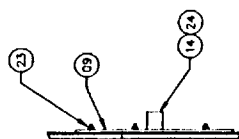
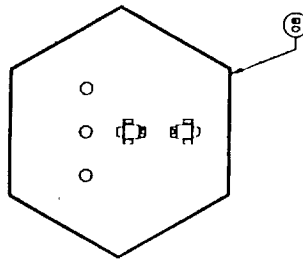
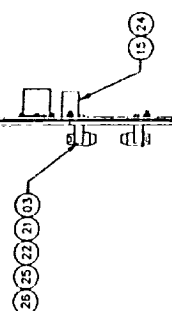
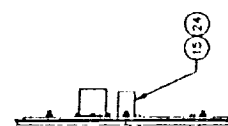
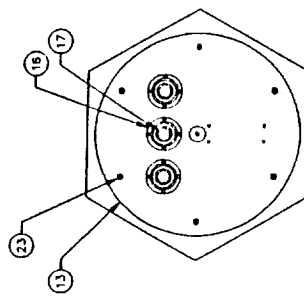
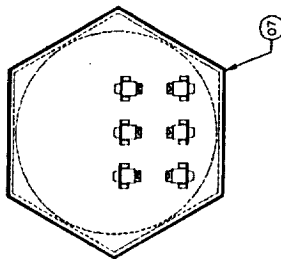
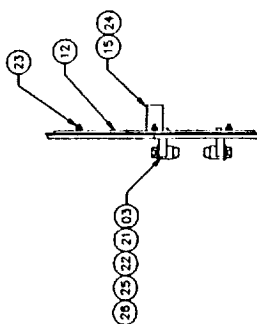
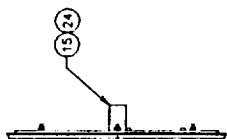
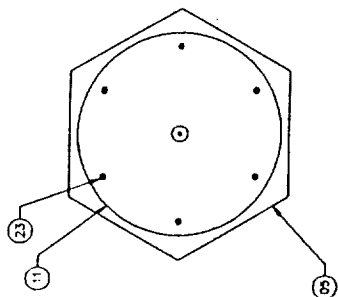
# **ANNEX C**

## **SYSTEM DRAWINGS**



VIEW SHOWN WITH REAR  
HEMI REMOVED

<b>LOGO</b> 		<b>SPHERE ASSY, CSTM-US-400-SL-TILED</b> 10-00-14	
THIS DRAWING AND THE INFORMATION CONTAINED HEREIN IS THE PROPERTY OF LASPHERE, INC. AND CANNOT BE DISCLOSED OR REPRODUCED IN ANY MANNER WITHOUT THE WRITTEN AUTHORIZATION OF LASPHERE, INC.		DRAWN BY: [ ] CHECKED BY: [ ] DATE: [ ]	
LASPHERE, INC. 10-00-14		SHEET 1 OF 3	



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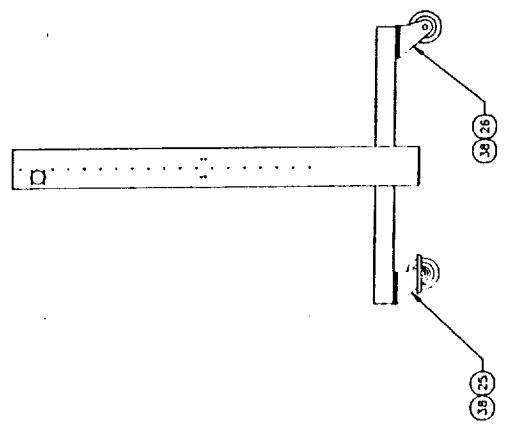
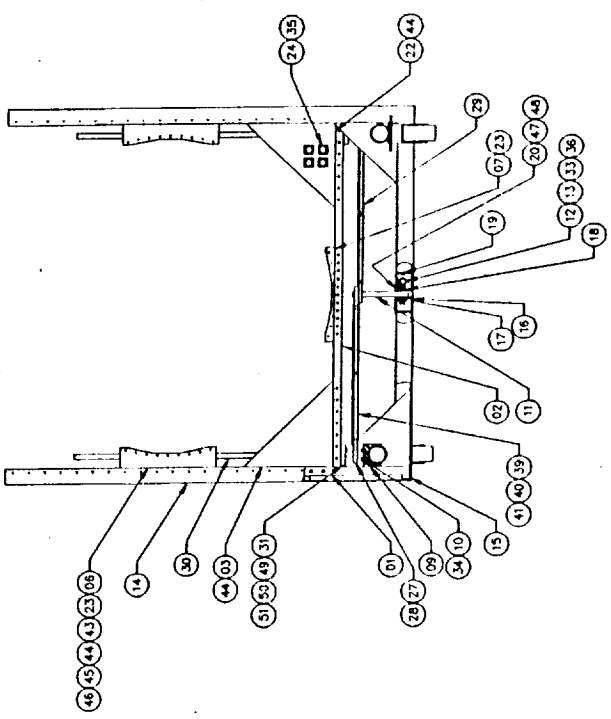
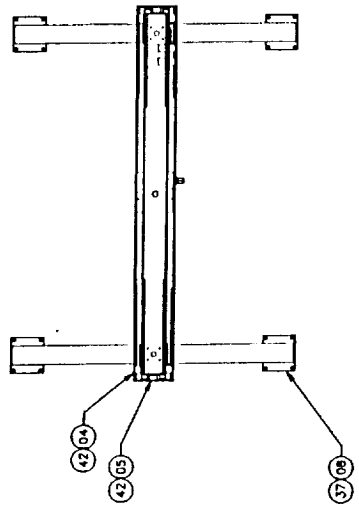
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Acct RICHM Process 0170

Single Level BOM for Part CY-01446-060 Sphere assy, 40.000  
40 INCH DIAMETER SPECTRALON TILED SPHERE

Effective as of 01-05-94

Bal	Component	Component	Item Desc	UM	Type	Quantity	Ref
Nbr	Item Number			CPN	CPN	Per Assy	Des
	CM-06642-000		Hemisphere, 40.00, D.	EA	FM	1.000	
02	SS-00013-031		Hemisphere, 40.000	EA	HE	1.000	
03	CM-06624-000		Mount, Lamp	EA	FM	32.000	
04	CM-06625-000		Tile, Penatagon, SL	EA	FM	9.000	
05	CM-06626-000		Tile, Hexagonal, SL	EA	FM	16.000	
06	CM-06653-000		Tile, Penatagon, Lamp	EA	FM	3.000	
07	CM-06652-000		Tile, Hexagonal, Lamp	EA	FM	2.000	
08	CM-06636-000		Tile, Hexagonal, Detector	EA	FM	1.000	
09	CM-06628-000		Plate, Backing, Small	EA	FM	9.000	
10	CM-06630-000		Plate, Backing, Small, Lamp	EA	FM	3.000	
11	CM-06629-000		Plate, Backing, Large	EA	FM	16.000	
12	CM-06631-000		Plate, Backing, Large, Lamp	EA	FM	2.000	
13	CM-06635-000		Plate, Backing, Large-	EA	FM	1.000	
14	CM-06632-100		Post, Mounting, Tile	EA	FM	12.000	
15	CM-06632-200		Post, Mounting, Tile	EA	FM	19.000	
16	CM-06637-010		Mount, Detector	EA	FM	3.000	
17	CM-06633-010		Tube, Detector	EA	FM	3.000	
18	CM-06639-000		Stud, Mounting, Aperture	EA	FM	6.000	
19	CM-06640-000		Washer, Stud, Mounting	EA	FM	6.000	
20	CM-06665-000		Filler, Gap	EA	FM	84.000	
21	CM-06671-000		Spacer, Mount, Lamp	EA	FM	64.000	
22	OC-04006-000		Skt, Lamp S-26 600v 3000w	EA	OP	32.000	
23	PP-00540-000		Bolt, Flat Head	EA	HW	179.000	
24	HW-00007-015		Scr, PhFlh 8-32x0.385	EA	HW	128.000	
25	HW-00007-022		Scr, SchCap 8-32x0.758	EA	HW	64.000	
26	HW-00005-020		Scr, PhBdgh 4-40x0.255	EA	HW	64.000	
27	HW-00012-005		Scr, SchCap 1/4-20x0.508	EA	HW	32.000	



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Acct RICHM Process 0170

Single Level BOM for Part CY-01447-000 Carriage assy, 40.00  
 STANDARD 40 INCH CARRIAGE MODIFIED TO BE HEIGHT ADJ. NOMINAL  
 HEIGHT 4-12 INCHES  
 Effective as of 01-05-94

Bal Nbr	Component Item Number	Component Item Desc	UM CPN	Type CPN	Quantity Per Assy	Re De
01	CM-06582-010	Upright, Frame	EA	FM	2.000	
02	CM-06583-010	Bottom, Frame	EA	FM	1.000	
03	CM-06584-010	Gusset, Frame	EA	FM	3.000	
04	CM-06585-000	Slide	EA	FM	4.000	
05	CM-06586-000	Slide	EA	FM	2.000	
06	CM-06587-010	Bracket, Side	EA	FM	2.000	
07	CM-06588-010	Bracket, Bottom	EA	FM	1.000	
08	CM-06589-010	Plate, Caster	EA	FM	4.000	
09	CM-06590-010	Block, End, Screw	EA	FM	2.000	
10	CM-06591-000	Cap, Thrust Washer	EA	FM	2.000	
11	CM-06593-000	Shaft, Pulley	EA	FM	1.000	
12	CM-06594-000	Shaft, Worm	EA	FM	1.000	
13	CM-06595-000	Bushing, Worm	EA	FM	2.000	
14	CM-06596-000	Mod., Carriage	EA	FM	1.000	
15	CM-06627-010	Block, Limit	EA	FM	8.000	
16	CM-06656-000	Bushing, Shaft, Gear	EA	FM	1.000	
17	CM-06657-000	Bushing, Shaft, Gear	EA	FM	1.000	
18	CM-06658-000	Mod., Wormgear	EA	FM	1.000	
19	CM-06659-010	Cover, Wormgear	EA	FM	1.000	
20	CM-06660-010	Brace, Shaft	EA	FM	1.000	
22	CM-06664-010	Gusset, Frame, Connectors	EA	FM	1.000	
23	CM-06670-010	Spacer, Frame	EA	FM	18.000	
24	CM-06677-000	Shroud, Connector	EA	FM	4.000	
25	PP-00537-000	Caster, 4D., 4Pos SWVLCK	EA	HW	2.000	
26	PP-00538-000	Caster, 4D., Swivel w/Brake	EA	HW	2.000	
27	PP-00532-000	Pulley, Belt, 18 Tooth	EA	HW	4.000	
28	PP-00536-000	Bushing, Tapered	EA	HW	4.000	
29	PP-00533-000	Belt, Timing, 3/8 Pitch	EA	HW	2.000	
30	PP-00534-000	Ball Screw, 5/8"x30"	EA	HW	2.000	
31	PP-00535-000	Ball Nut, 5/8" w/Flange	EA	HW	2.000	
32	PP-00529-000	Gear, Worm	EA	HW	1.000	
33	PP-00530-000	Worm	EA	HW	1.000	
34	PP-00531-000	Bearing, Thrust	EA	HW	2.000	
35	EC-12039-012	Conn, 97-3102A-16-11P-639	EA	EL	4.000	
36	PP-00553-000	Key, 3/16x3/16x1	EA	HW	1.000	
37	HW-00012-010	Scr, PhFlh 1/4-20x0.75B	EA	HW	16.000	
38	HW-00009-000	Scr, SchCap 3/8-16x0.75B	EA	HW	16.000	
39	CM-06721-010	Plate, Tensioner	EA	FM	4.000	
40	CM-06722-000	Spacer, Tensioner	EA	FM	12.000	
41	CM-06723-000	Roller, Tensioner	EA	FM	8.000	
42	HW-00005-005	Scr, SchCap 4-40x0.38B	EA	HW	114.000	
43	HW-00007-016	Scr, PhFlh 8-32x0.50B	EA	HW	22.000	
44	HW-00007-015	Scr, PhFlh 8-32x0.38B	EA	HW	89.000	
45	HW-00007-004	Scr, SchCap 8-32x0.50B	EA	HW	27.000	
46	HW-02003-001	Wshr, Flat #8 B	EA	HW	27.000	
47	HW-00005-021	Scr, Phbdgh 4-40x0.38B	EA	HW	4.000	
49	HW-00012-007	Scr, SchCap 1/4-20x0.75B	EA	HW	8.000	
50	HW-01008-000	Nut, Hex 1/4-20x0.44 S	EA	HW	8.000	



SLB.BY.BALLOON

Labsphere, Inc.

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Acct RICHM Process 0170

Single Level BOM for Part CY-01447-000 Carriage assy, 40.00  
STANDARD 40 INCH CARRIAGE MODIFIED TO BE HEIGHT ADJ. NOMINAL  
HEIGHT +-12 INCHES  
Effective as of 01-05-94

Bal Component Nbr Item Number	Component Item Desc	UM CPN	Type CPN	Quantity Per Assy	Rel Des
51 HW-02006-004	Wshr, Lk Split 1/4 B	EA	HW	8.000	